IN THE CLAIMS

The following listing of claims will replace all prior versions, and listings, of claims in the application.

1. (Currently Amended) A method for estimating at least a subset of symbol sequences from received signals at multiple receivers in a multiple receiver communication system wherein each of said multiple receivers receives a sum of signals from a plurality of transmitters sharing the same communication medium, wherein said signals are formed by a sequence of contiguous symbols, each of which occupies a fixed time duration, and samples said received signals with a time interval that is the inverse of an integer multiple of said fixed time duration, wherein said integer multiple is no smaller than the number of said signals divided by the number of said receivers, wherein the channels of said signals have finite impulse response and are different from one another, said symbol estimation method comprises:

(a) sampling said received signals at multiple receivers with a time interval equal to a $\frac{1}{F}$ fraction of said fixed time duration, wherein F, an integer is no smaller than $\frac{J}{M M_t}$, wherein J is the number of said transmitters, M is the number of said receivers, M_t is a positive integer, and generating Q sampled received signals from each of said received signals, wherein Q is an integer no larger than M_t;

(b) constructing data vectors from sampled received signals by filtering them with channel responses between said transmitters and said receivers and multiplexing ~~the~~ outputs of said filtering;

(c) obtaining the maximum length of the channel responses of users at multiple receivers, which is denoted as d+1, and constructing a channel response matrix for each receiver; [[,]]

(d) constructing space-time correlation matrices with said channel response matrices;

(e) constructing a second set of matrices and vectors computed from said space-time correlation matrices and said data vector;

(f) applying a recursive bisection approach on said second set of matrices and vectors to generate an output sequence, wherein said recursive bisection approach comprises:

forward division steps which recursively compute a first series of matrices and vectors initially based on said second set of matrices and vectors and yield vectors in said first series of vectors and matrices with $dJ\lfloor L_i/2 \rfloor$ rows where dJL_i is the number of rows of the last element in said first series of vectors and matrices, until a pre-defined stopping criterion is satisfied, where $\lfloor x \rfloor$ denotes the floor function evaluated on x ~~means the smallest integer which is not smaller than x~~, wherein L_i is an integer variable which is updated in each of said forward division steps,

backward substitution steps which first construct an intermediate solution with the last of the first series of matrices and vectors and recursively compute, in a reverse order of said forward division steps, a second series of vectors with said first set of matrices and vectors until exhausting all of said first set of matrices and vectors; and

(g) demultiplexing the vector from the last in said second series of vectors; whereby said symbols of said signals are found from said output sequence.

2. (Original) The symbol estimation method in claim 1 wherein said channels are convolutions of physical channels and their corresponding pulse shaping filters of said channels.

3. (Original) The symbol estimation method in claim 1 wherein said channels are convolutions of physical channels and their corresponding spreading codes of said signals in a code-division-multiple-access communication system.

4. (Original) The symbol estimation method in claim 1 wherein said channels are convolutions of physical channels, their corresponding spreading codes of said signals, and their corresponding pulse shaping filters in a code-division-multiple-access communication system.

5. (Currently Amended) The symbol estimation method in claim 1 wherein said channel response matrix comprises channel filter responses.

6. (Original) The symbol estimation method in claim 1 wherein the vectors in said second set of matrices and vectors are constructed by adding up said data vectors.

7. (Currently Amended) The symbol estimation method in claim 1 wherein each of said channel response matrices is constructed for each said receiver by putting the channel filter responses between said transmitters and said receiver as columns in a matrix according to the user index, zeros are padded to said channel response matrices if necessary so that the number of rows in all said channel response matrices is the smallest integer multiple of ~~of~~ the maximum channel response length.

8. (Original) The symbol estimation method in claim 1 wherein said space-time correlation matrices are constructed by adding up the correlation results of channel response matrices.

9. (Currently Amended) The symbol estimation method in claim 1 wherein the matrices in said second set of matrices and vectors comprises three matrices A_1, B_1, and D_1 which are constructed by first finding the maximum length of channel filter responses of all users, padding zeros to channel filter responses whereby all of them are of d+1 symbol durations wherein d is the least integer possible, constructing d time correlation matrices for each receiver with d matrices obtained from dividing the channel filter responses at that receiver into d+1 parts, constructing d spatial-time correlation matrices for multiple receivers by adding up the time correlation matrices for all receivers with the same time shift, constructing A_1 according to a block-Toeplitz structure with spatial-time correlation matrices 0, …, d-1, constructing B_1 according to another block-Toeplitz structure with spatial-time correlation matrices -1, …, -d, and finally assigning A_1 to D_1.

10. (Currently Amended) The symbol estimation method in claim 1 wherein said first series of matrices and vectors comprises a series of three $dJ \times dJ$ channel description matrices which are A_i the ordinary diagonal block matrix, B_i the superdiagonal block matrix, D_i the special diagonal block matrix, and a right-hand vector which is divided into $dJ \times 1$ blocks which are indexed from one. [[;]]

11. (Currently Amended) The symbol estimation method in claim 1 wherein said forward reduction step further comprises putting said second set of matrices and vectors as the first of said first series of matrices and vectors and computing recursively new channel description matrices from the latest channel description matrices and a new right-hand vector with blocks from linear combinations of blocks of even index and their neighboring blocks in the last right-hand vector.

12. (Currently Amended) The symbol estimation method in claim 1 wherein said pre-defined stopping criterion is that the length of the latest generated right-hand vector is dJ or that the superdiagonal block matrix in the latest of said first series of matrices and vectors becomes a zero matrix.

13. (Original) The symbol estimation method in claim 1 wherein said backward substitution step further comprises solving the equations as defined by the latest of said first series of matrices and vectors, putting latest channel description matrices and the solution as the first of said second series of matrices and vectors, assigning the blocks of the vector of the latest in said second series of matrices and vectors to the even blocks of a new vector and computing the odd blocks of the new vector from these blocks and corresponding right-hand vectors.

14. (Currently Amended) The symbol estimation method in claim 1 wherein said d spatial-time correlation matrices T_i, i = 0, …, -d, are constructed by

$$\sum_{m=1}^{M}\sum_{n=1}^{d+i}(H_{d+1-n}^{(m)})^{*}\,H_{(d+1-n+i)}^{(m)} + \delta(i)\nu I$$

where the channel response matrix H_i at receiver m, m=1, …, M, consisting of (d+1)J rows, where d+1 is said maximum channel response length, and J columns, which are the channel responses from transmitters to the receiver m, is related to $H_m^{(n)}$, n = 1, …, d+1 by

$$H_i = \begin{bmatrix} H_m^{(1)} \\ H_m^{(2)} \\ \vdots \\ H_m^{(d+1)} \end{bmatrix},$$

where $\delta(\cdot)$ is the Kronecker function, ν is the variance of noise for minimum-mean-square-error joint detection and 0 for zero-forcing joint detection.

15. (Original) The symbol estimation method in claim 1 wherein said second set of matrices and vectors consists of channel description matrices A_1, B_1, D_1 and Y_1 where A_1 is composed of $d \times d$ blocks, and the (i,j) block is T_{-j+i} if j≥i, and T_{-j+i}^{*} if j<i; B_1 is composed of $d \times d$ blocks, and the (i,j) block is T_{-d+j-i} if i≥j, and $0_{J\times J}$ if i<j; D_1 is A_1^{*}; and Y_1 is $\sum_{m=1}^{M} R_i$ where R_i is said signal obtained from receiver i.

16. (Original) The symbol estimation method in claim 1 wherein said second set of matrices and vectors are $B_i^{*}A_i^{-1}$, $B_iA_i^{-1}$, $B_iD_i^{-1}$ if L_i is odd, X_{i+1}, and Y_i, for backward substitution step i, i = s, s-1, …, 1.

17. (Currently Amended) The symbol estimation method in claim 1 wherein said forward division step comprises for forward division step i, i = 1, …, s,

$$A_{i+1} := -B_i^{*}A_i^{-1}B_i + A_i - B_iA_i^{-1}B_i^{*}$$

$$B_{i+1} := -B_iA_i^{-1}B_i$$

$$B_{i+1}^{*} := -B_i^{*}A_i^{-1}B_i^{*} \qquad \cancel{(41)}$$

$$Y_{i+1,k} := -B_i^* A_i^{-1} Y_{i,2k-1} + Y_{i,2k} - B_i A_i^{-1} Y_{i,2k+1},\ k=1, \ldots, \left\lfloor \frac{L_i - 3}{2} \right\rfloor$$

$$D_{i+1} := A_i - B_i D_i^{-1} B_i^* - B_i^* A_i^{-1} B_i$$

$$L_{i+1} := \tfrac{1}{2}(L_i - 1) \qquad \cancel{(42)}$$

$$Y_{i+1,L_{i+1}} := -B_i^* A_i^{-1} Y_{i,L_i-2} + Y_{i,L_i-1} - B_i^* D_i^{-1} Y_{i,L_i}$$

if Li is odd;

$$D_{i+1} := D_i - B_i^* A_i^{-1} B_i$$

$$L_{i+1} := \tfrac{1}{2} L_i \qquad \cancel{(43)}$$

$$Y_{i+1,L_{i+1}} := -B_i^* A_i^{-1} Y_{i,L_i-1} + Y_{i,L_i}$$

if Li is even.

18. (Currently Amended) The symbol estimation method in claim 1 wherein said pre-defined <u>stopping</u> criterion is $L_{i+1}=1$ or $B_{i+1}=0$, s is set to i+1 and the forward reduction steps stop.

19. (Original) The symbol estimation method in claim 1 wherein intermediate solution step comprises solving $D_s X_s = Y_s$.

20. (Currently Amended) The symbol estimation method in claim 1 wherein said backward substitution step i, i = s, …, 1, comprises<u>:</u>

$$X_{i,1} = A_i^{-1} Y_{i,1} - A_i^{-1} B_i X_{i+1,1},$$

$$X_{i,2k+1} = A_i^{-1} Y_{i,2k+1} - A_i^{-1} B_i^* X_{i+1,k} - A_i^{-1} B_i X_{i+1,k+1},\ 1 \le 2k+1 < L_i, \qquad \cancel{(44)}$$

$$X_{i,L_i} = D_i^{-1} Y_{i,L_i} - D_i^{-1} B_i^* X_{i+1,L_{i+1}} \text{ if } L_i \text{ is odd.}$$

21. (Currently Amended) A method for estimating at least a subset of symbol sequences from a received signal at a receiver in a communication system, the method comprising:

(a) oversampling said received signal, thereby producing a plurality of received signal sample sets;

(b) constructing data vectors from the received signal sample sets;

(c) obtaining the maximum length of the channel responses of users at multiple virtual receivers, which is denoted as d+1, and constructing a channel response matrix for each receiver;

(d) constructing space-time correlation matrices with said channel response matrices;

(e) constructing a second set of matrices and vectors computed from said space-time correlation matrices and said data vector;

(f) generating an output sequence by applying a recursive bisection approach on said second set of matrices and vectors, wherein said recursive bisection approach comprises:

forward division steps which recursively compute a first series of matrices and vectors initially based on said second set of matrices and vectors and yield vectors in said first series of vectors and matrices with $dJ\lfloor L_i/2 \rfloor$ ~~dJ[L_i/2]~~ rows where dJL_i ~~dJL_1~~ is the number of rows of the last element in said first series of vectors and matrices, until a pre-defined stopping criterion is satisfied, where $\lfloor x \rfloor$ is the floor function evaluated on x ~~[x] means the smallest integer which is not smaller than x~~, wherein L_i is an integer variable which is updated in each of said forward division steps,

backward substitution steps which first construct an intermediate solution with the last of the first series of matrices and vectors and recursively compute, in a reverse order of said forward division steps, a second series of vectors with said first set of matrices and vectors until exhausting all of said first set of matrices and vectors; and

(g) detecting symbols in the received signal by demultiplexing the vector from the last in said second series of vectors; whereby said symbols in the received signal are found from said output sequence.

22. (Original) The method of claim 21, wherein each of said multiple receivers receives a sum of signals from a plurality of transmitters sharing the same communication medium, wherein said signals are formed by a sequence of contiguous symbols, each of which occupies a fixed time duration, and samples said received signals with a time interval that is the inverse of an integer multiple of said signals divided by the number of said receivers, wherein the channels of said signals have finite impulse response and are different from one another.

23. (Currently Amended) The method of claim 21, wherein said oversampling said received signal is performed at multiple receivers with a time interval equal to a 1/P fraction of said fixed time duration, wherein P is an integer no smaller than $\underline{J/(MM_t)}$ ~~J/MM_t~~, wherein J is the number of said transmitters, M is the number of said receivers, M_t is a positive integer and generating Q sampled received signals from each of said received signals wherein Q is an integer no larger than M_t.

24. (Currently Amended) The method of claim 21, wherein said constructing includes constructing the data vectors from the sampled received signals by filtering them with channel responses between said transmitters and said receivers and multiplexing ~~the~~ outputs <u>of said filtering</u>.